

THURSDAY, AUGUST 11, 1910.

## RECENT EARTHQUAKE INVESTIGATIONS.

*The California Earthquake of April 18, 1906.* Report of the State Earthquake Investigation Committee (in two vols. and atlas). Vol. ii., *The Mechanics of the Earthquake.* By Harry F. Reid. Pp. viii + 192. (Washington: Carnegie Institution, 1910.)

ON the average a little earthquake occurs in the world every fifteen minutes. Great earthquakes occur on the average about every four days, but it is only on rare occasions that they hit populated districts. The majority of the latter originate beneath deep oceans or in uninhabited mountain regions, and as neither little fish nor wandering tribes write letters to the *Times*, all we know about their occurrence comes from the observations of enthusiastic seismologists. Nineteen hundred and six, however, was a bad year for humanity, and exhibitions of seismic relief took place in many districts. On January 31 a great disaster occurred in Colombia. On April 4 many soldiers and natives lost their lives in the Kangra Valley. On April 14 nearly 6000 houses fell in Formosa, whilst four days later San Francisco and other towns in Central California were reduced to ruins. On June 14, Kingston, in Jamaica, was badly shattered, and in the autumn, on August 17, Valparaiso and Santiago fell. In connection with the disaster at San Francisco, British shareholders in insurance companies were called upon for twelve million pounds, whilst towards the reconstruction in Kingston their contribution was two millions. What they paid for the happenings in other parts of the world I do not know, but it is quite certain that attention was directed to the fact that even the inhabitants of the British islands were not entirely beyond the pale of the vagaries of *Mater Terra*.

In 1906 the proprietors of newspapers, lawyers, expert witnesses, the vendors of building materials, constructors, and others may have regarded earthquakes as blessings in disguise. The charitably disposed had frequently opportunities to derive comfort from their donations, while scientific bodies saw opportunity for investigations. The International Seismological Association spent a very large sum in collecting and reproducing seismograms relating to the earth movements which had devastated Central Chile. The Carnegie Institution of Washington not only carried on similar work for the earthquake of California, but by publishing three volumes based on the material collected it has considerably extended our knowledge connected with seismological observations.

To the first two of these volumes, issued as part i. and part ii., reference has been made already (*NATURE*, March 4, 1909, vol. lxxx., p. 10). The second volume, by Prof. H. F. Reid, of the Johns Hopkins University, which is now before us, treats of "*The Mechanics of the Earthquake.*" In the discussion on the origin of the shock, this is shown to have taken place from point to point along a line of fracture many miles in length and with a variable depth. There are therefore

many times of origin, each of which depends upon the particular point considered. This may be a seismometrical refinement, but Prof. Reid, by his insistence on this, has done much towards the exact understanding of certain observations. In the discussion on permanent displacements of the ground we are shown that as the results of three surveys, the first of which commenced in 1851, there have been permanent displacements parallel to the length of a well-known fault. The ground on the east side of this fault has moved southwards, whilst that on the opposite side of it has gone to the north. A part of this displacement, no doubt, took place at the time of the earthquake, but there are convincing reasons for the belief that much of it took place gradually before the earthquake. The ground, in fact, was bent before it broke. By experiments with a stiff slab of jelly across which a slight cut made by a knife represented a line of fault, the nature of the strain which takes place before and after an earthquake is illustrated. The actual forces required to produce in solid rock the observed distortions, which resulted in rupture, are given in mechanical units. If the depth of the fault was 12.5 miles, its length 270 miles, and the average movement 13 feet, then the work done at the time of rupture is estimated at  $13 \times 10^{16}$  foot-pounds. After this energy was set free, seismographs throughout the world were set in motion.

A cause for the deforming forces which resulted in these strains is sought for in the theory of isostasy, which implies that the shifting of materials accompanying surface denudation is compensated for by a sub-surface flow. By this flow a dragging force is exerted upon the superincumbent crust, which from time to time yields suddenly. To predict tectonic earthquakes we should build a line of piers at right angles to a fault line and determine from time to time the difference in direction between these piers and their relative levels. Such observations, whether they did or did not prove of value as an assistance towards earthquake prediction, it is extremely likely that they would throw light upon certain branches of earth physics. Rotary movements are considered at some length, and the idea that they may be the result of vibrations at right angles is considered to be the one offering the simplest explanation.

A chapter of great interest, not only to the builder, but to the mathematician, relates to the influence of a foundation upon apparent intensity, this being most pronounced upon alluvium.

Part ii. of this volume is devoted to a critical description of seismograms obtained from stations in various parts of the world. This is followed by old and new explanations for the apparent increase in the duration of an earthquake as it travels. This is another good chapter, but it might easily have been extended. The discussion of the velocities with which different wave types were propagated and the paths they may have followed has been worked out with great care, and is distinctly instructive. The determination of the distance of the origin of an earthquake, as is now well known, depends upon the interval of time between the arrival of the first motion and the arrival of

some other phase of motion like the large waves. This is closely examined, and observations previously made upon this point are brought more closely in accord.

Disturbances of magnetic needles at the time of the earthquake have not been overlooked. Much is said in favour of damping pendulums, and reference is made to the recently devised "dead-beat" instruments of Prince Galitzin. We have not, however, come across any reference to his method of determining the direction of an earthquake from the first of the preliminary tremors. The monograph closes with the theory of the seismograph. In this we notice the statement that the instruments designed by myself in 1892 and Dr. Schlüter about 1903, to show tilting of the ground at the time of an earthquake failed to show such a phenomenon. This is only true for the latter instrument (see British Association Report, 1893, p. 222).

Prof. Reid's memoir is a valuable contribution to the mechanics of earthquakes. He has ploughed both new ground and old, and seismologists will thank him for the material he has furnished for their consideration.

JOHN MILNE.

#### TAR, ACID, AND ALKALI.

- (1) *Coal Tar and Ammonia*. By Prof. George Lunge. Fourth and enlarged edition. Part i., pp. xix+563; part ii., pp. xiii+564-1178. (London: Gurney and Jackson, 1909.) Price 42s. net, two vols.
- (2) *The Manufacture of Sulphuric Acid and Alkali, with the Collateral Branches: a Theoretical and Practical Treatise*. Third edition, enlarged. By Prof. George Lunge. Vol. ii., part i., Sulphate of Soda, Hydrochloric Acid, Leblanc Soda, pp. xx+490; vol. ii., part ii., ditto, pp. xii+491-1010. (London: Gurney and Jackson, 1909.) Price 42s. net, two parts.

THESE three terms—tar, acid, and alkali—stand for the most important of the determining factors of chemical technology. Round them may be ranged practically everything that relates to the business of applied chemistry. In its most comprehensive sense, each in turn may be regarded as the parent or genital substance from which flows a countless number of bodies, forming by their mutual actions and reactions the vast array of products which modern manufacturing chemistry has placed at the service of mankind. In the works before us, Dr. Lunge's treatment of these themes is worthy of their importance. The works themselves have already taken an assured position in the literature of chemical technology. In each successive edition their veteran author strives to make them a faithful and adequate reflection of the state of contemporary knowledge and achievement, thereby tending, so long as his ministering care is available, to make that position secure. They have long been recognised as indispensable to the technologist, and each new issue is certain of an immediate welcome.

The volume on coal-tar and ammonia is now in its fourth edition. What enormous changes have come over the industry of tar production, and of the

extraction and utilisation of the innumerable substances which enter into its composition, will be evident from even the most superficial examination of the several issues. The rate of progress, indeed, transcends anything to be observed in any other branch of manufacture. Only nine years have elapsed since the third edition made its appearance, but such has been the accumulation of new material in that interval that practically the whole of the chapters—eleven in number—dealing with coal-tar and its products have had to be revised and in great part rewritten. In this section of the work Dr. Lunge has had the assistance of Dr. Kraemer, of Berlin, an acknowledged authority in this branch of chemical technology.

England is still the great tar-producing country of the world, but her supremacy in this respect is threatened by the United States. Tar is mainly obtained from gas-works, from blast furnaces, and from coke-ovens. In the United Kingdom the annual production at the present time approaches a million tons—obtained by the destructive distillation of about seventeen or eighteen million tons of coal—an amount exceeding that of the whole of Europe put together, and probably more than twice the aggregate yield of Germany and France. This country, where benzene was discovered by Faraday, where its industrial extraction was worked out by Mansfield, and where the first aniline colour was made by Perkin, has become simply as the hewer of wood and the drawer of water in this matter. We make the tar, but apparently we can do little with it except sell it to the Germans in order that they shall turn it into that astonishing array of manufactured products which their admirable system of scientific training has taught them how to produce. When in the hour of her humiliation Germany set herself to reconstruct the educational system which has culminated in her present scheme, she forged the most powerful instrument of national development which human forethought could have devised. With it has come her extraordinary commercial development and her ambition to be supreme in the world's markets, and with it, too, she thinks, has come the necessity of being able to protect that commerce, if necessary, by force of arms. What becomes of coal-tar may seem a small matter in determining the course and destiny of nations. But it is absolutely certain that if our university system had been developed, even *pari passu* with that of Germany, and that if those who were responsible for the government of this country, and those who seek to form public opinion, had paid more heed to the signs of the times, we should to-day have less talk about Tariff Reform and of the imperative necessity of more "Dreadnoughts." If Peace has her victories, no less renowned than those of War, we may well ask ourselves if we have always gone the right way to work to secure the victories of peace.

Dr. Lunge's second work—that on sulphuric acid and alkali, now in its third edition—further serves to illustrate the same text. If there was one chemical industry more than another in which Great Britain